Mars Capability Roadmaps:

- Robotic Access to Planetary Surfaces (Team 6)
- Human Planetary Landing Systems (Team 7)

Rob Manning (Chair CRM Team 7)
Mark Adler (Chair CRM Team 6)
Bobby Braun (Co-Chair CRM Team 6)

Roadmap Status

- *Both roadmaps are a work in progress, but they have already accomplished a great deal without publishing a page.*
  - *They have for the first time brought the bulk of the past and present robotic and human landing system community together for frank discussions of where we are and where we need to go.*
  - *They have identified that this community is weaker and spread more thin since the dawn of these efforts in the 1960s.*
  - *We are ill-equipped to support the necessary paradigm shifts for these future systems because of the near-exclusive use of heritage systems for the past 30 years.*
    - *E.g. the last instrumented system was in the early to mid 1980s.*
- *There have been two workshops for each of the two roadmaps. The roadmaps themselves have not been drafted.*

Expected Mars Robotic Access Capabilities - In ten years …

- *Assumes new entry technology development, nuclear powered surface elements:*
- *One+ metric ton payloads to the surface of Mars (translates to, for example, 100+ kg science payloads on rovers)*
- *High latitude, all season, one or more Martian year lifetime, up to +2 km altitude (MOLA) access*
- *Precision (~ 5 km) landing accuracy*
- *Kilometers per week traverse*
- *Gigabit per day data return*
- *Rock subsampling*
- *Complex sample handling and processing for in situ laboratory use and for sample collection*
- *Collection and transport of 500g samples from Mars to Earth (with associated planetary protection capabilities)*

Expected Mars Robotic Access Capabilities - In twenty years +

- *Deep drilling (10 m to 10's of m)*
- *Kilometers per day traverse*
- *Pinpoint (~ 100 m) landing accuracy*
- *Steep terrain access*
- *Short-duration Martian aircraft*
- *Aerocapture for increased mass to low Mars orbit*
- *Further growth in landed mass or returned mass dependent on new launch vehicle developments (beyond current capability of Delta IV Heavy — perhaps driven by exploration program needs)*
- *Subscale Human Mars landers, as driven by exploration program needs*
- *In thirty years ….*
  - *Hopefully have humans assisting the robotic exploration of Mars*

Mars Robotic Paradigm Shifts:

- *Nuclear powered surface systems — paradigm shift back to Viking (MSL to provide)*
- *New supersonic parachute development post-Viking*
  - *See Cook's discussion.*
- *New thermal protection system (heat shield material) development for higher heat rates*
- *Descent terrain-matching sensing for pinpoint landing*
- *Significant computational capability (hardware and software) on surface for higher rate traverse*
- *Laser communications trunk from Mars to Earth*

Rough robotic program assumptions:

- *MSL in '09 and related capabilities are a given*
- *Mars Scouts are a wild card that could provide additional capability maturation.*
- *Mars sample return next decade (drives landed mass, PP capabilities)*
- *Large (astrobiology) field laboratory next decade*
- *Deep drill following decade*
- *Mars airplane following decade*
- *No assumptions (yet) about transition to human-scale landing systems — in work with Human Landing roadmap group*

Expected Mars Human Landing Capabilities - In ten years …

- *Assumes objective be able to get EDL systems that can safely deliver 40 - 60 MT of useful payload on Mars qualified for flight by 2030 and full scale flight by 2035.*

- *NASA funds effort to do significant pre-project systems analysis of Human Scale landing systems by 2010.*
- *Earth-based flight tests of small scaled hypersonic and transonic systems are initiated for technology viability.*
- *A detailed technology and systems validation roadmap is certified by 2010.*
- *MSR determines (or not) that there is no ubiquitous biohazard at the surface (especially in global dust).*

Expected Mars Capabilities - In twenty years +

- *By 2025 in-situ and sample return robotic systems and orbiters have enabled selection and certification of the first Human landing site(s).*
- *A complex of GPS-like and other in-situ navigational aids have been deployed that make precision and pin-point landing navigation highly reliable.*
- *Phase A human-scale landing system development occurs.*
- *Full scale Earth hypersonic and transonic tests of key subsystems of the baseline Human-scale landing system have been completed.*
- *Orbiter missions specifically designed to monitor decadal atmosphere density, winds, dust transport, and pressure cycle have been initiated.*
- *Full or Subscale flight test at Mars launched.*

- *In thirty years ….*
  - *First full scale (> 40 MT) unmanned cargo and/or human landing.*

Paradigm shifts:

"Abort to Surface" EDL reliability strategy + very high reliability.

(vs Apollo's "abort to orbit")

EDL velocity control:

Double entry OR Aerocapture OR efficient propulsion (nuclear thermal)

AND

New mid L/D hypersonic systems OR

New low ballistic coefficient systems OR

New high L/D (high altitude) hypersonic aircraft

AND

New large scale propulsion system OR

New supersonic decelerator(s)

AND

New medium scale propulsion systems

Rough assumptions:

- *The efforts made in 2005-2015 will resolve some of the key unknowns in 2005:*
  - *How to deal with the Supersonic -> subsonic transition and associated configuration changes.*
  - *How to manage energy reliabily to land above 0 km and still have enough time to get to within 100 m of other landed assets.*
  - *How to achieve "4 nines" of reliability including environmental variables like dust (high tau), climatic and weather variations and surface character.*
  - *How to deal with planetary protection and bio-hazards.*
- *Reliable precision and pin-point landing navigation data types have been developed, validated and deployed by robotic program.*
- *Mars landing site and environmental surveys completed by robotic program.*
- *Since the Robotic program's test infra-structure is insufficient for development of the large human-scale systems, sufficient funding will have been allotted toward test infrastructure development and maintenance.*

Robotic Access and HPLS Roadmap Schedule

Feb-4: Each sub-team to review and revise their portion of the CBS

Feb-18: Each sub-team to develop a draft of their input

Feb-22: First draft of report available

- look at/for coupling with other capability and strategic RM

Mar 3-4 at JPL: Third and final team meeting – mostly report work

Mar-9: Near-final version of report complete

Mar-14: NRC charts dry-run

Mar 23-24: NRC Review